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DISCLOSURE TEXT:

Disclosed is an invention that describes an automated approach to achieving a high degree of accuracy when aligning a probing system with the device to be tested, utilizing a camera and vision system to automate the device alignment process.

Prior art, the alignment was accomplished using Hunt & Peck technique that is slow, lacking in robustness, and destructive.

Technical Background - Probing systems must be able to locate the test points of a product. These test points are usually given as coordinates relative to some origin on the surface of the product.

Probing systems require a means of locating the probes with respect to test points on a device to be tested. Device terminal or test sites are usually described in industry by orthogonal coordinate frames or grids.

Probes are usually positioned by orthogonal XY positioning table with XY coordinate frames. Regardless of the coordinate frame types a transformation is required to relate these two frames. Yielding this transformation will be referred to as the alignment process.

Alignment is done each time a device is loaded into the tool when the process and placement deviation is larger than the structures to be probed. A "hunt and peck" method may be used such that the probe is moved and actuated while using sensing feedback to identify the test site structures. This process can be slow, destructive, and lack robustness. This disclosure describes a method that utilizes a camera and vision system to automate the process of device alignment.

Using a monitor and optics the procedure may be accomplished manually so as to save the cost of the vision system.

This invention was implemented on a two probe system that provided two stacked XY cartesian stages each carrying a Z actuated probe. A camera is mounted at a fixed distance from the probe such that the view is roughly parallel, and in the same direction, as the actuating stroke of the probe. The product surface is parallel to the XY positioner. A flat surface is provided coplanar to the device to be probed such that probing the flat surface alters the appearance of the surface. The flat surface will be referred to as the reference and the probe mark as the reference point.

The following describes a two step alignment procedure.

The first step provides the offset between the center of the field of view of the camera and the probe tip. The second step provides the transformation that allows the camera to be centered on any test site on the surface of the product. The probe is positioned by noting the camera position and adding the probe offset. At the end of the

process a product coordinate can be used to position the camera or probe over the desired site.

The system XY positioner is moved such that an unused portion of the reference is located in the field of view of the camera. This position will be called the pre-probe position and is pre-imaged only when the vision system is incorporated into the routine. This location is taught and managed by the system software.

Note that when the positioner moves it can be moved in XY to known positions and by known distances by virtue of the position feedback provided by these systems. The image of the field of view is stored by the vision system. The system XY positioner is moved such that the probe is located over the unused portion of the reference. This relative motion is based on the nominal distance of the camera relative to the probe which is fixed by the mechanical design to some tolerance. By moving the XY positioner, the nominal XY distance between probe and camera, the probe should be over the point previously under the camera with some error. The error is the mechanical assembly tolerances and such things as probe wear are determined in this step.

The XY position is noted. The probe is actuated and the surface is altered in appearance. The camera is then returned to the pre-probe position.

A comparison of the previous image and the current image locates the probe position in the field of view of the camera (if a vision system is used). This mark is trained and used to center the camera on the mark. Since the XY position of the camera over probe mark is known and the XY position of the probe when it made the mark is known the exact offset between probe and camera is known. If a vision system is not used a reference point on a monitor is used and the operator must manually jog the XY and thus the camera so as to center on the probe mark.

If features on the product surface are centered in the field of view of the camera then they can be probed accurately using the offset obtained by the above procedure. However, it is not required to center all probe sites in the field of view of the camera prior to probing. The product test sites are usually defined by coordinates that relate the relative offsets of each test point relative to some arbitrary origin. By centering the camera on a test site, or other feature with a known set of coordinates, a coordinate transformation between product and tester may be derived. Note that the number of test sites, or reference features used, to derive the coordinate transformation between the XY positioner and product is a function of the transformation required.

In the current implementation of this invention the number of reference points obtained will result in particular compensation with assumptions as follows:

1. One - offset correction - assumes product coordinate frame is only translated with respect to the XY positioner
2. Two - offset, scale, and rotation correction - assumes product coordinate frame is only rotated and translated with respect to the XY positioner
3. Three - offset, rotation, X scale, Y scale, and shear
4. More than three - least squares fit

Centering the camera over a feature on the product is aided by a teach routine of the system software.

The camera can remember the location of the feature and reposition within placement and process tolerances. This allows the feature to show up in the field of view

of the camera. By training the image to a vision system, the vision system locates the object in the field of view of the camera. The camera is moved to center the object and a coordinate transformation is derived between the image coordinate frame and the positioner frame. If the image frame is calibrated to the positioner coordinate frame such that an offset in the camera frame implies an offset in the XY positioning frame then the feature need not be centered.

The above describes the alignment of one XY positioner and probe. This procedure is adaptable to the addition of another XY positioner with Z if the XY is orthogonal to the XY positioner carrying the camera.

If the XY cameras are not orthogonal then a camera must be attached to the other table if the correction is desired. The method is also applicable if the product and reference is moved by the XY positioner and the probe actuator is fixed. The method described herein has the following attributes and features:

1. Nondestructive
2. Highly Accurate Using Actual Probe Mark "End Point Sensing"
3. Relatively Low Cost
4. Automatic or Manual Operation

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